

[54] **RADIATION IMAGE READ-OUT APPARATUS**

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[52] **U.S. Cl.** **250/327.2; 250/484.1**

[58] **Field of Search** **250/327.2, 484.1, 370.07, 250/370.11; 378/146**

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[57] **ABSTRACT**

A radiation image read-out apparatus comprises a linear stimulating ray source for emitting stimulating rays to a linear portion of a stimuable phosphor sheet carrying a radiation image stored therein, and a line sensor constituted by many solid state photoelectric conversion devices. The line sensor extends at least over the length of the linear portion of the stimuable phosphor sheet exposed to stimulating rays. Light emitted by the linear portion of the stimuable phosphor sheet upon stimulation thereof is received and photoelectrically converted by the solid state photoelectric conversion devices. The portion exposed linearly to stimulating rays and the line sensor are moved with respect to the stimuable phosphor sheet, and outputs of the line sensor are sequentially read out in accordance with the movement of the portion exposed linearly to stimulating rays and the line sensor with respect to the stimuable phosphor sheet.

11 Claims, 3 Drawing Sheets

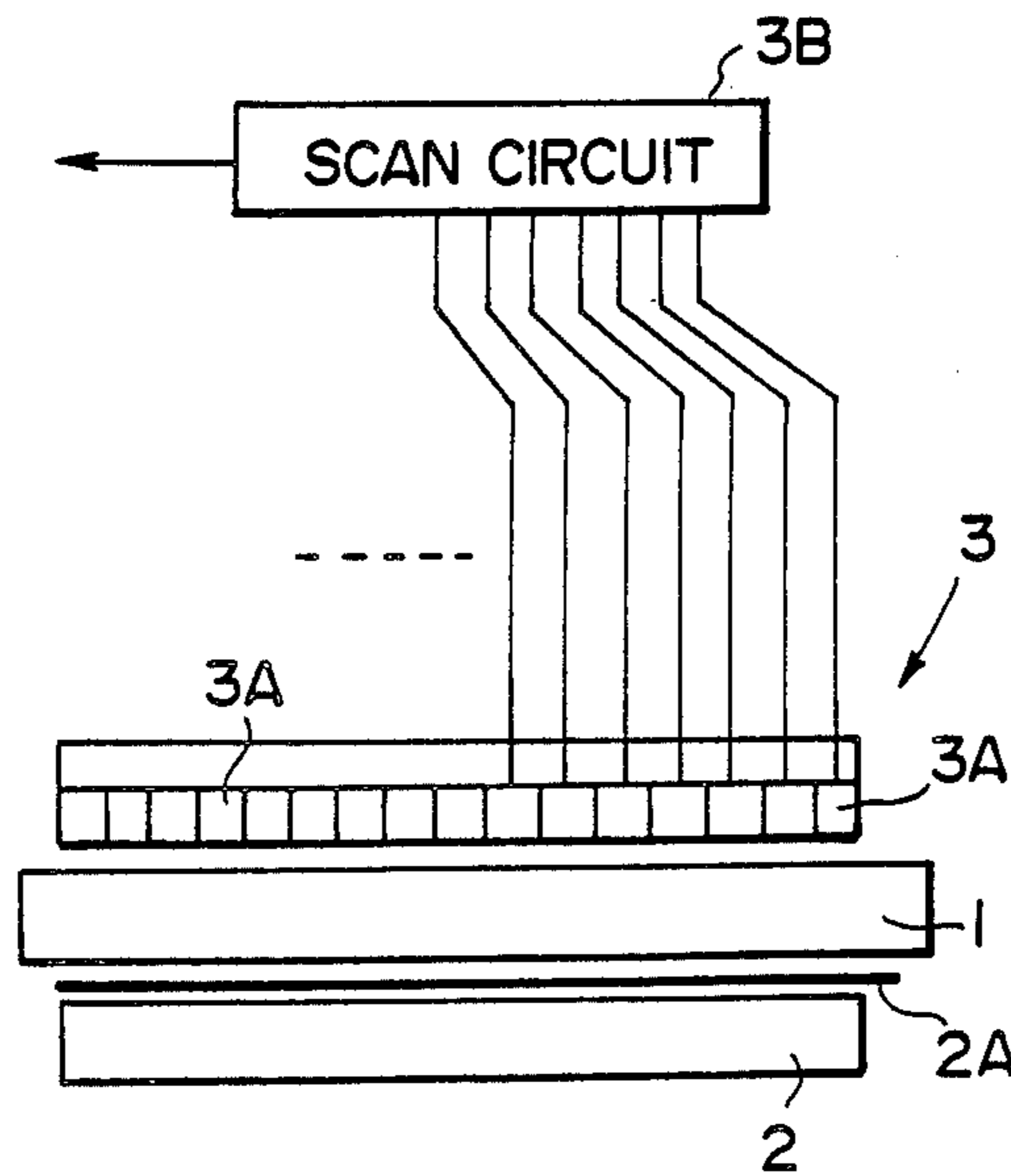


FIG. 1A

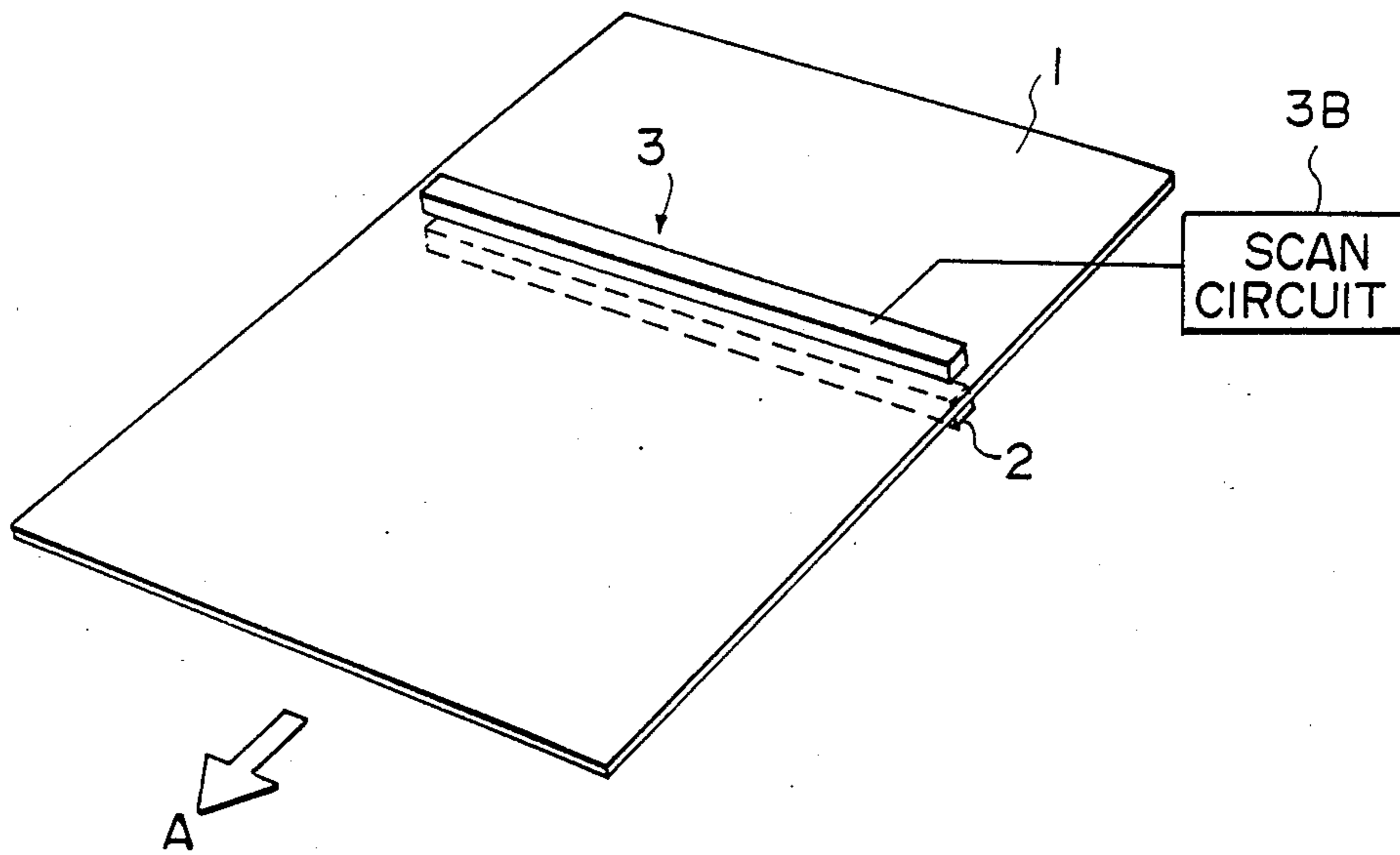


FIG. 1B

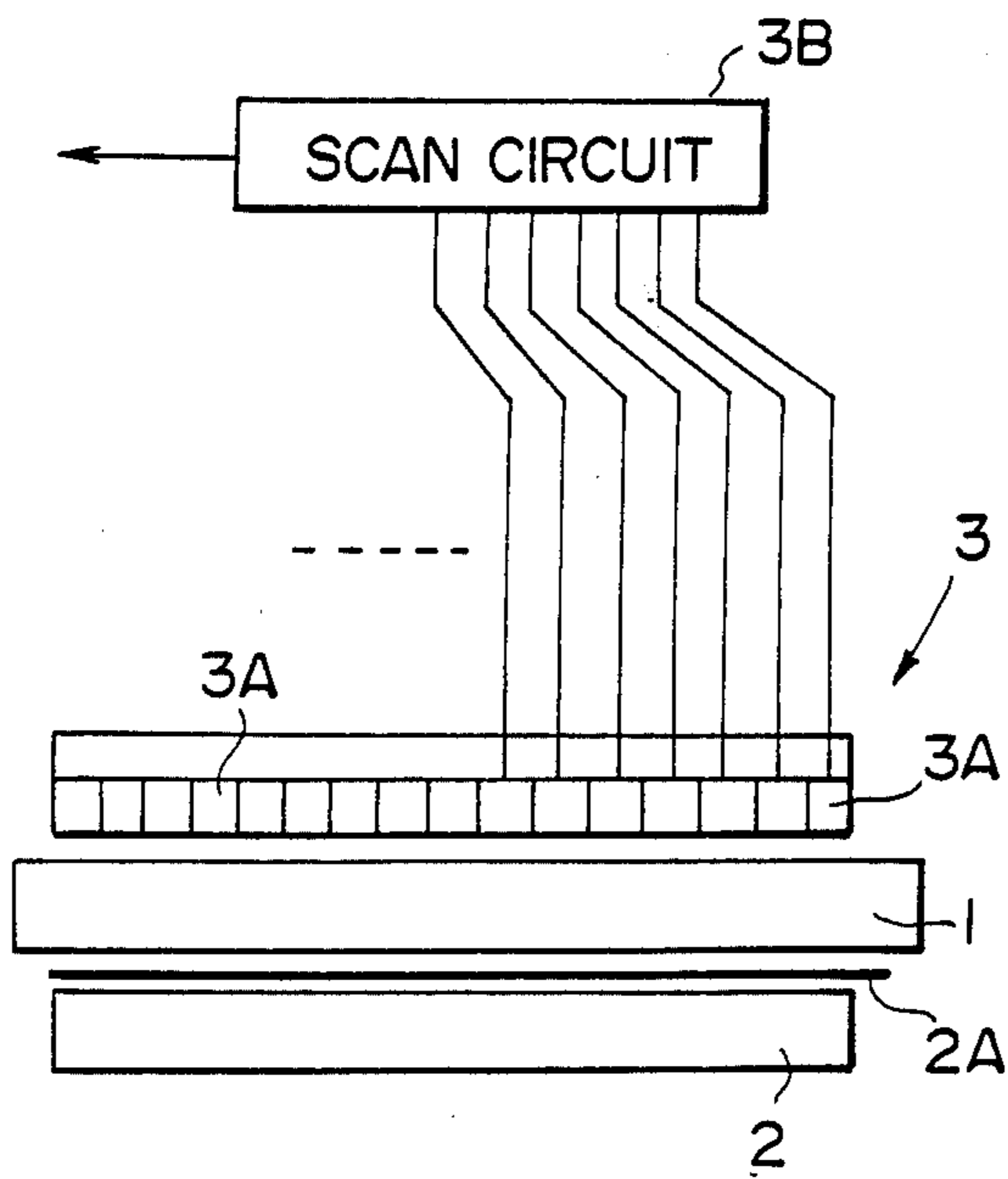


FIG. 1C

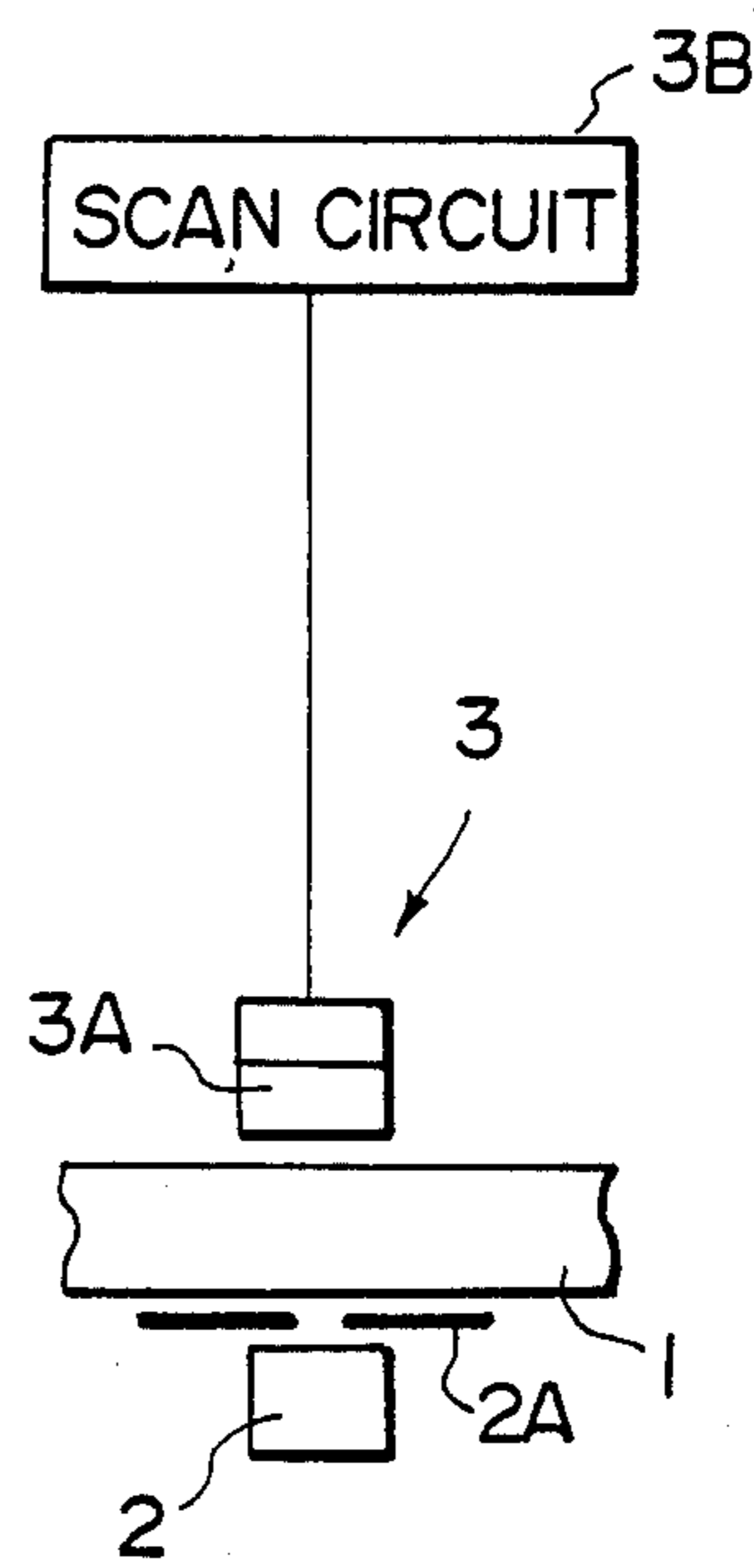


FIG. 2

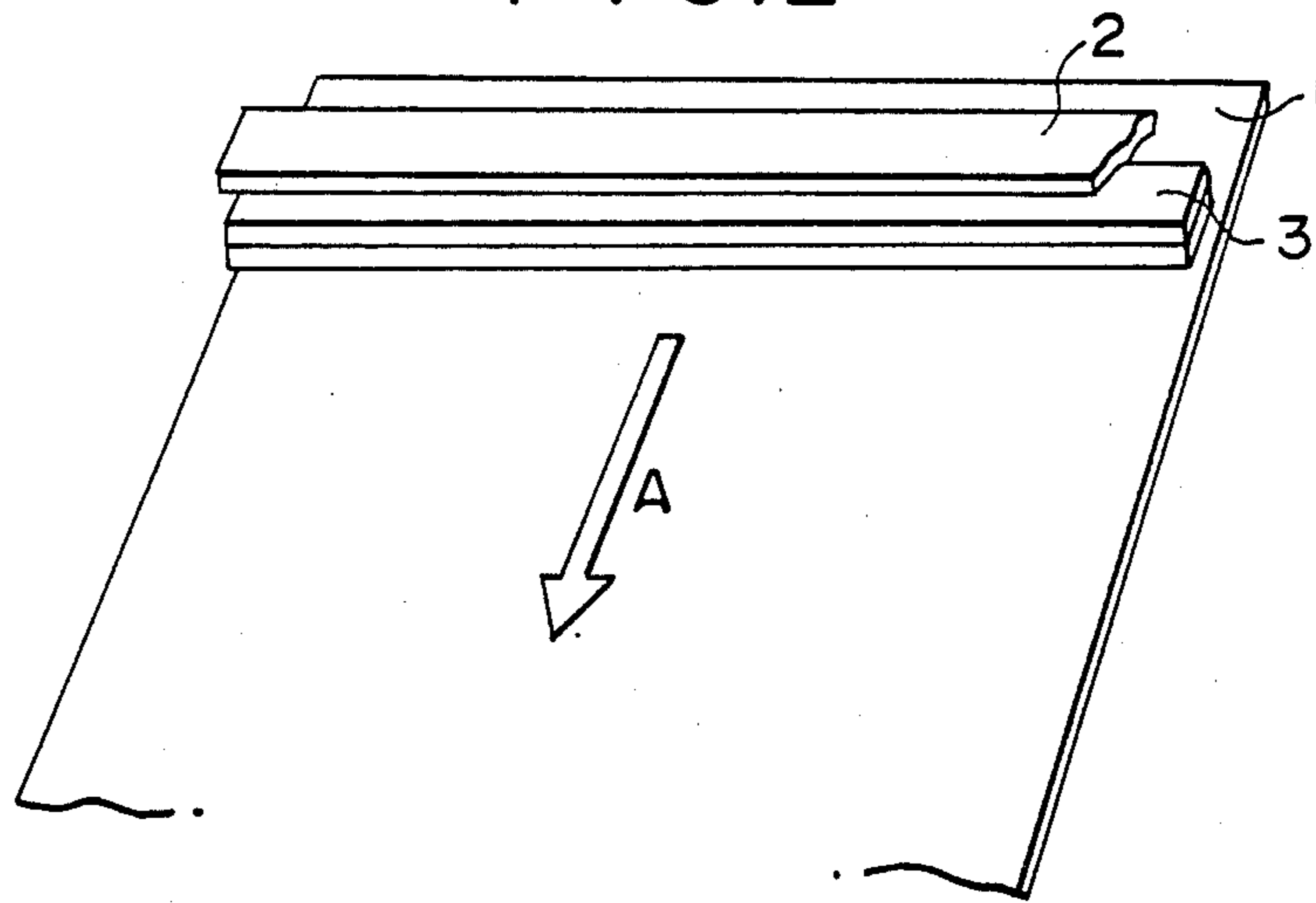


FIG. 3A

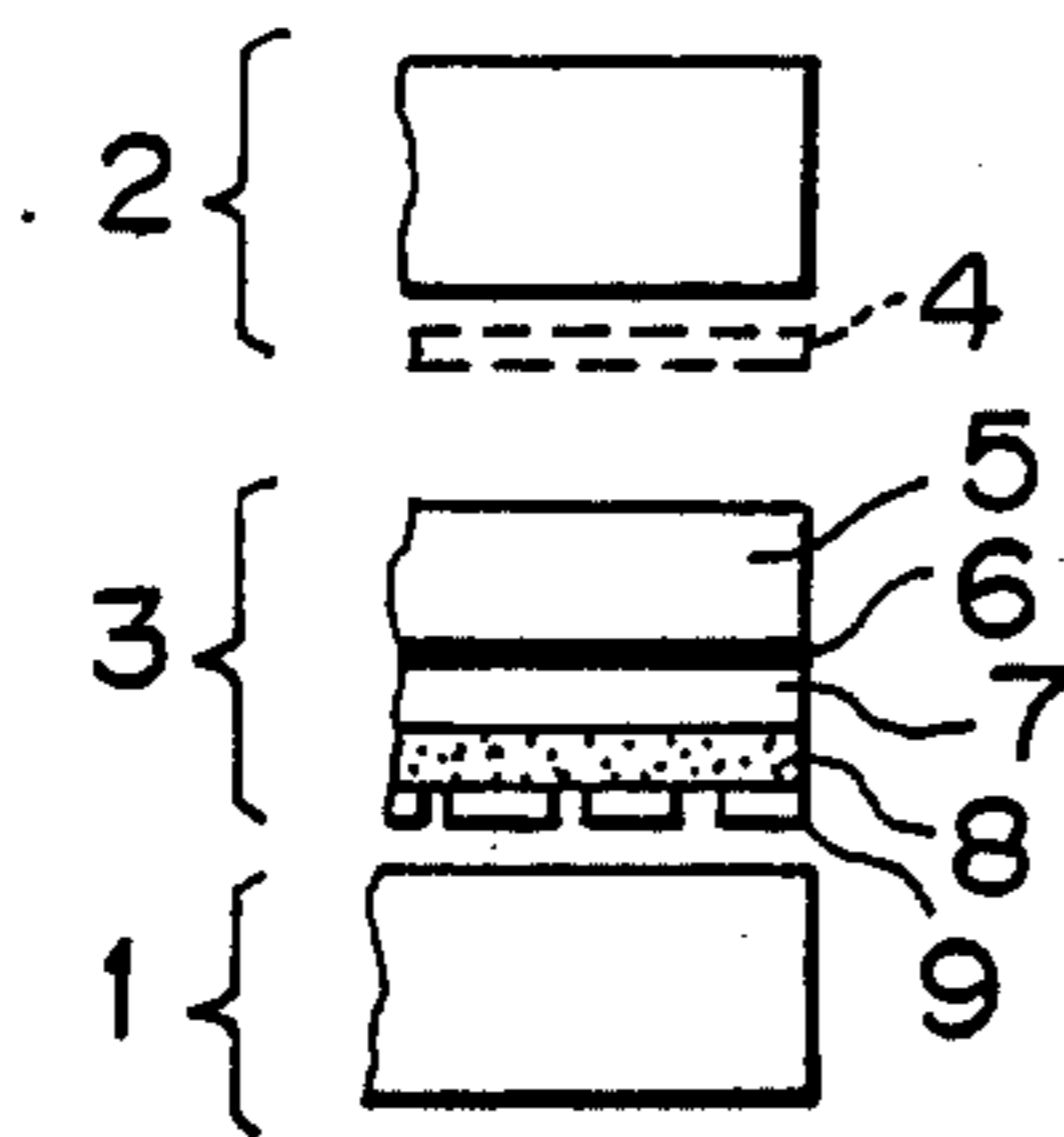


FIG. 3B

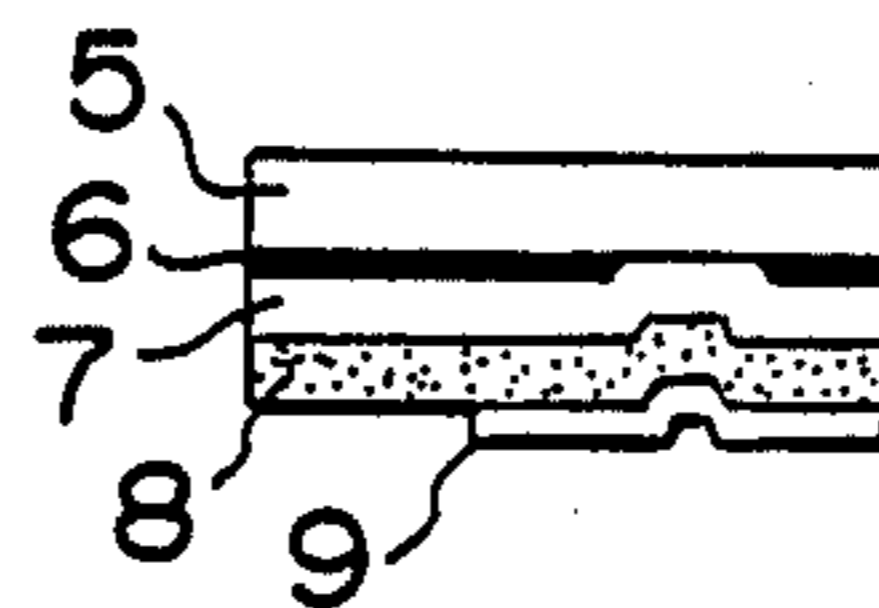


FIG. 4

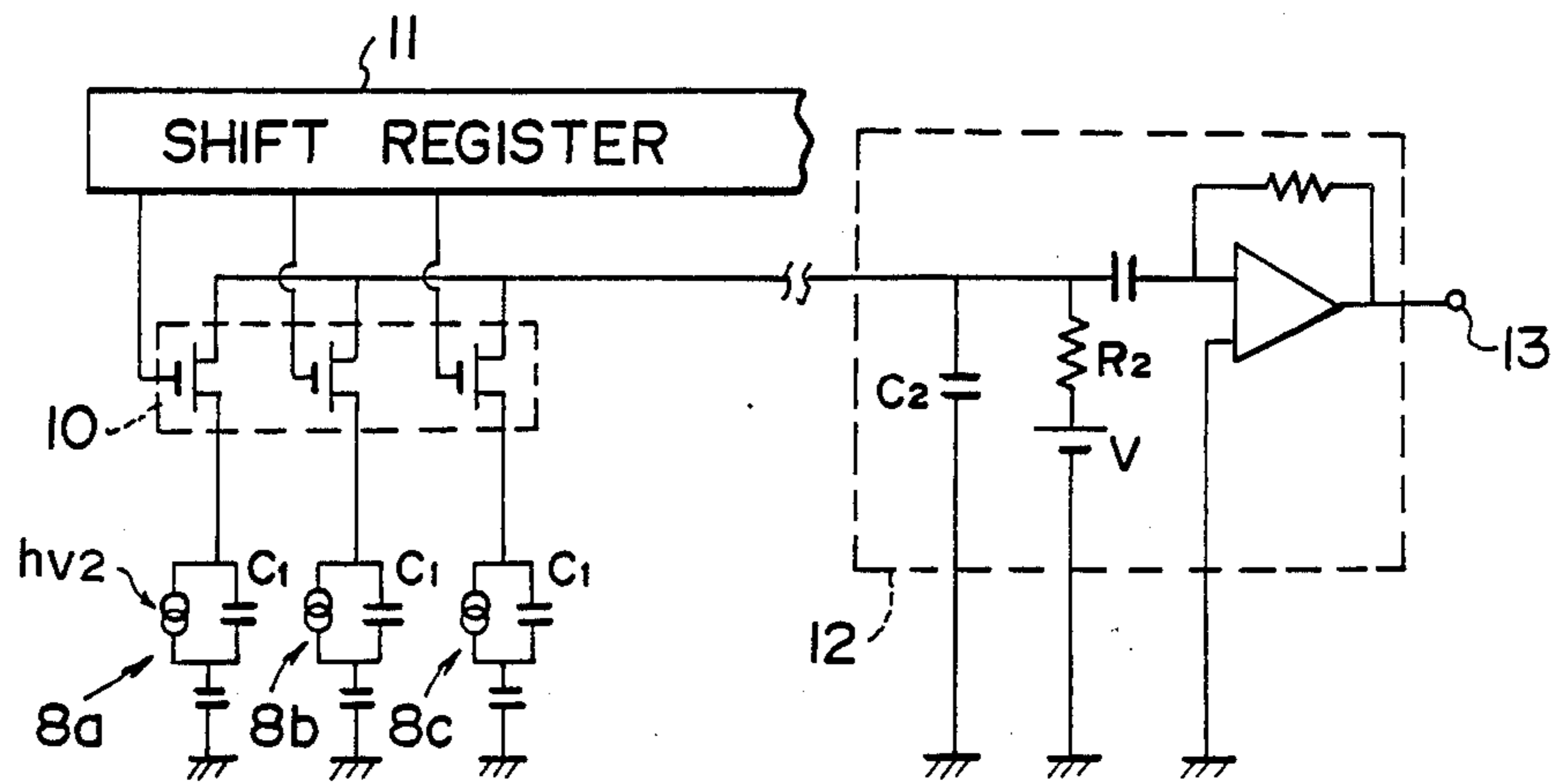


FIG. 5A

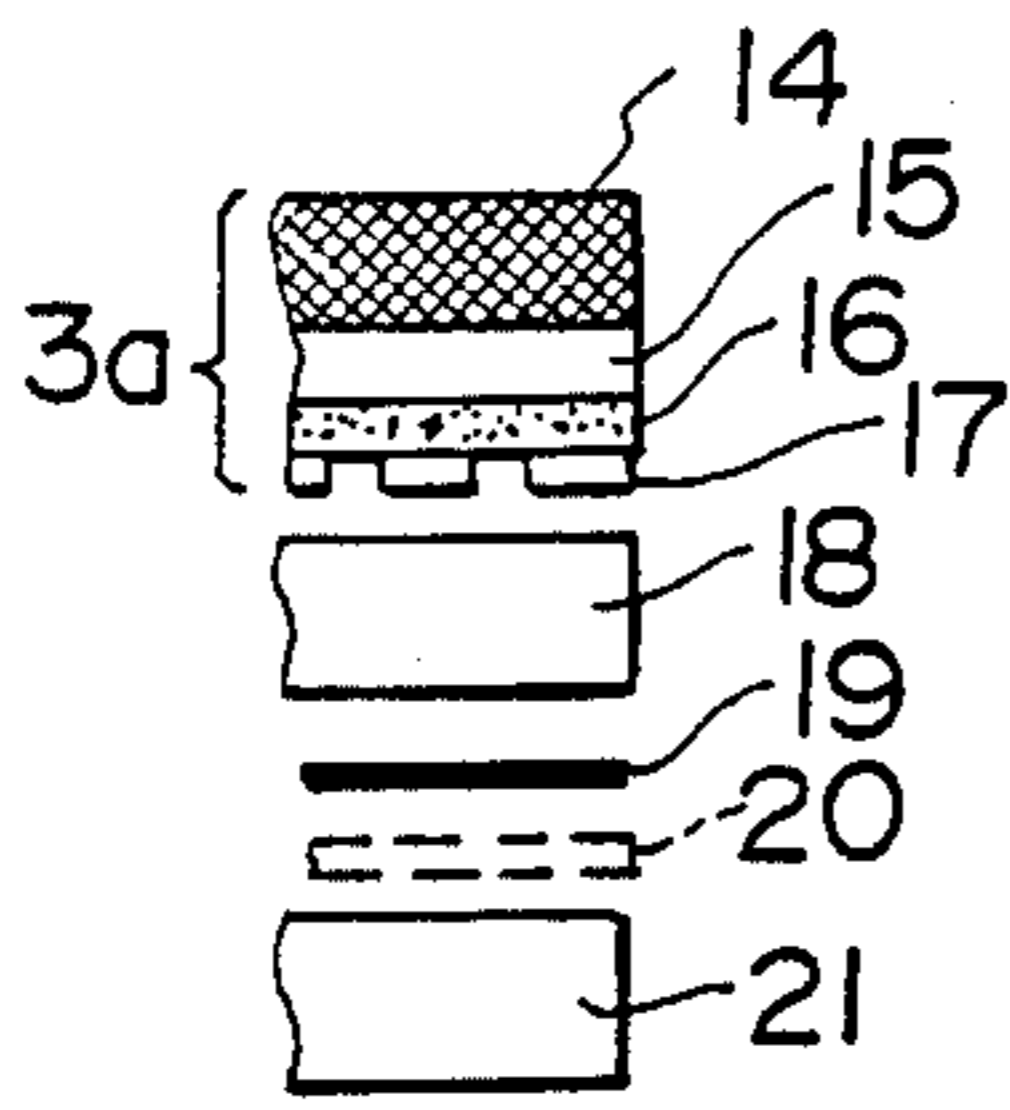


FIG. 5B

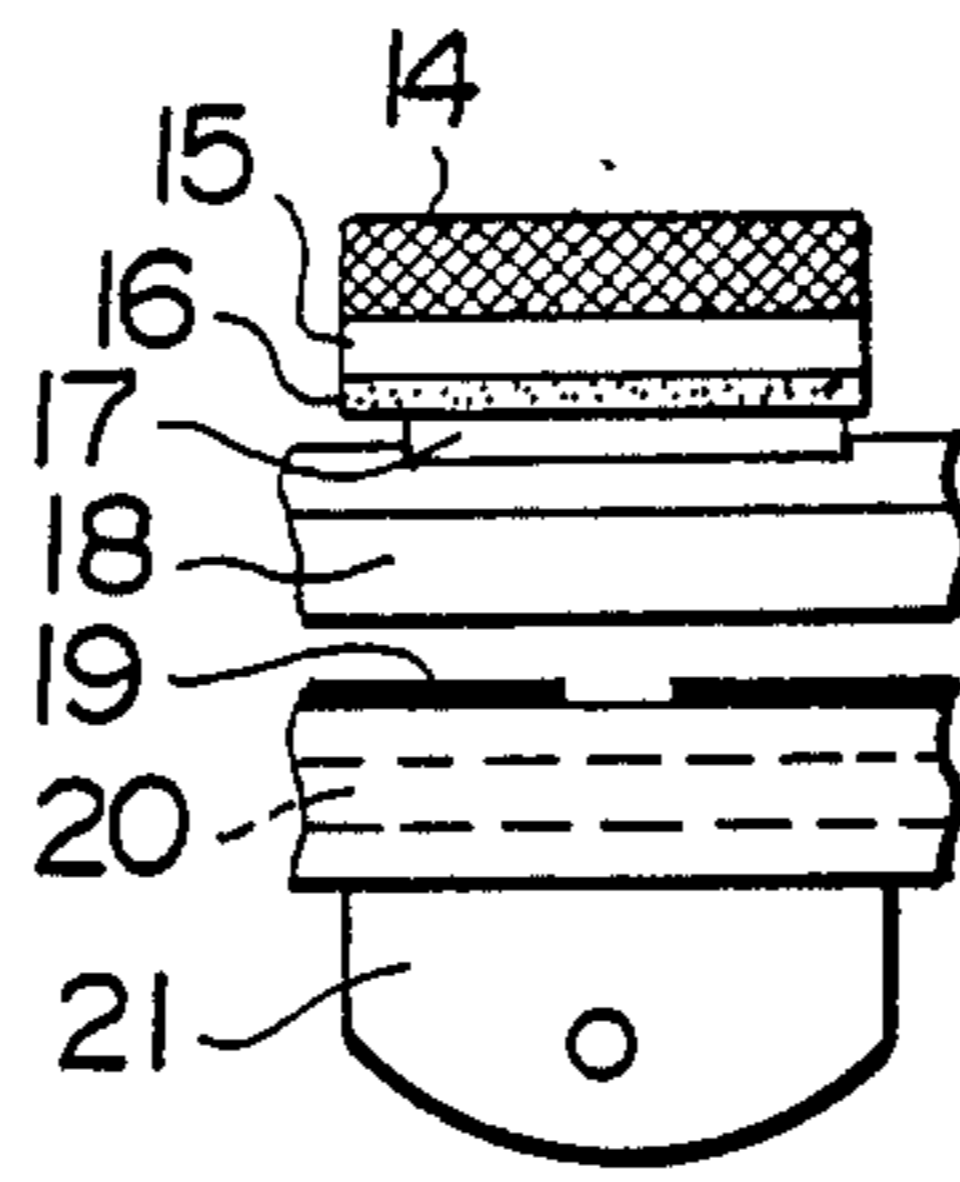


FIG. 6

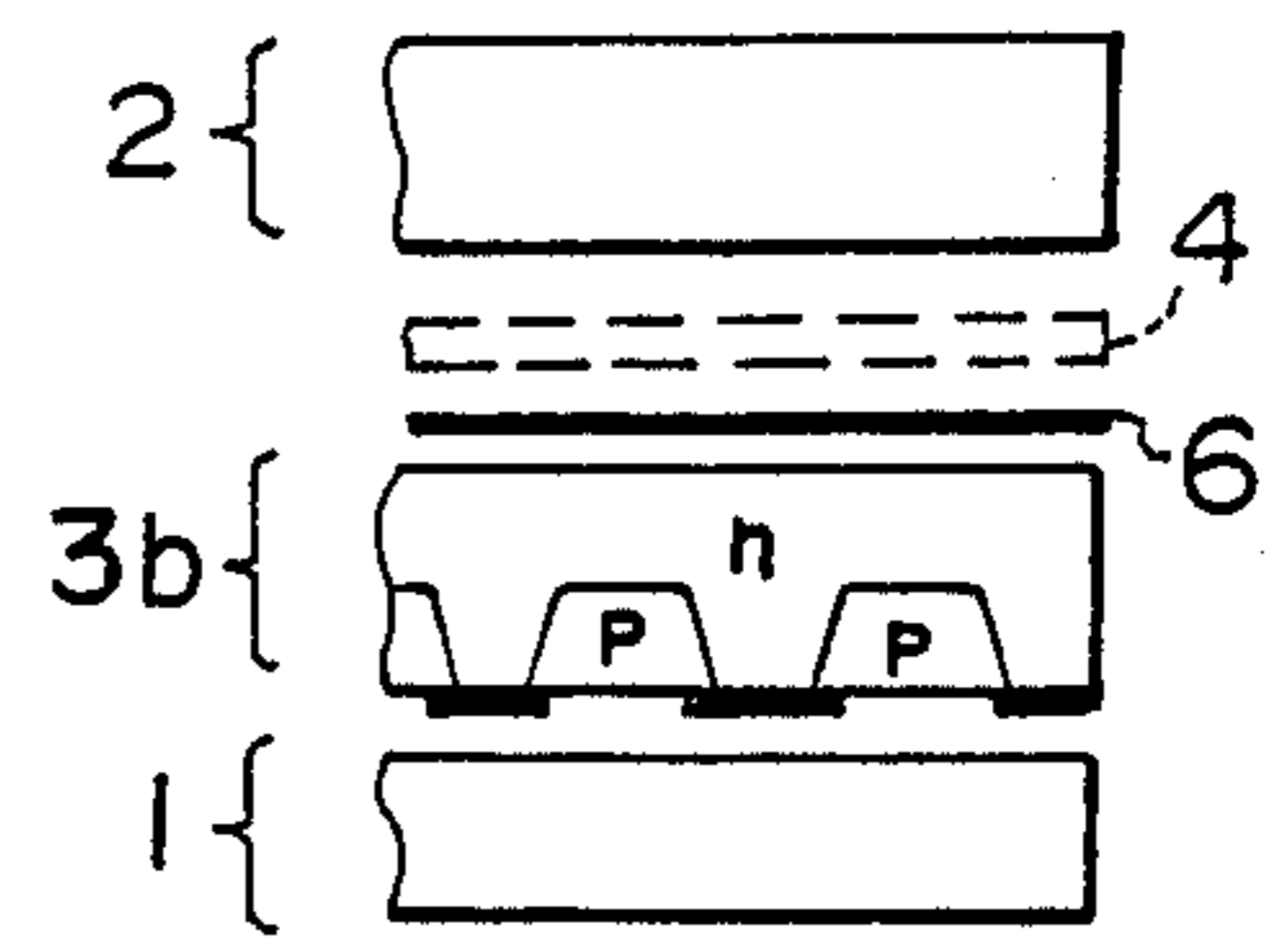


FIG. 7

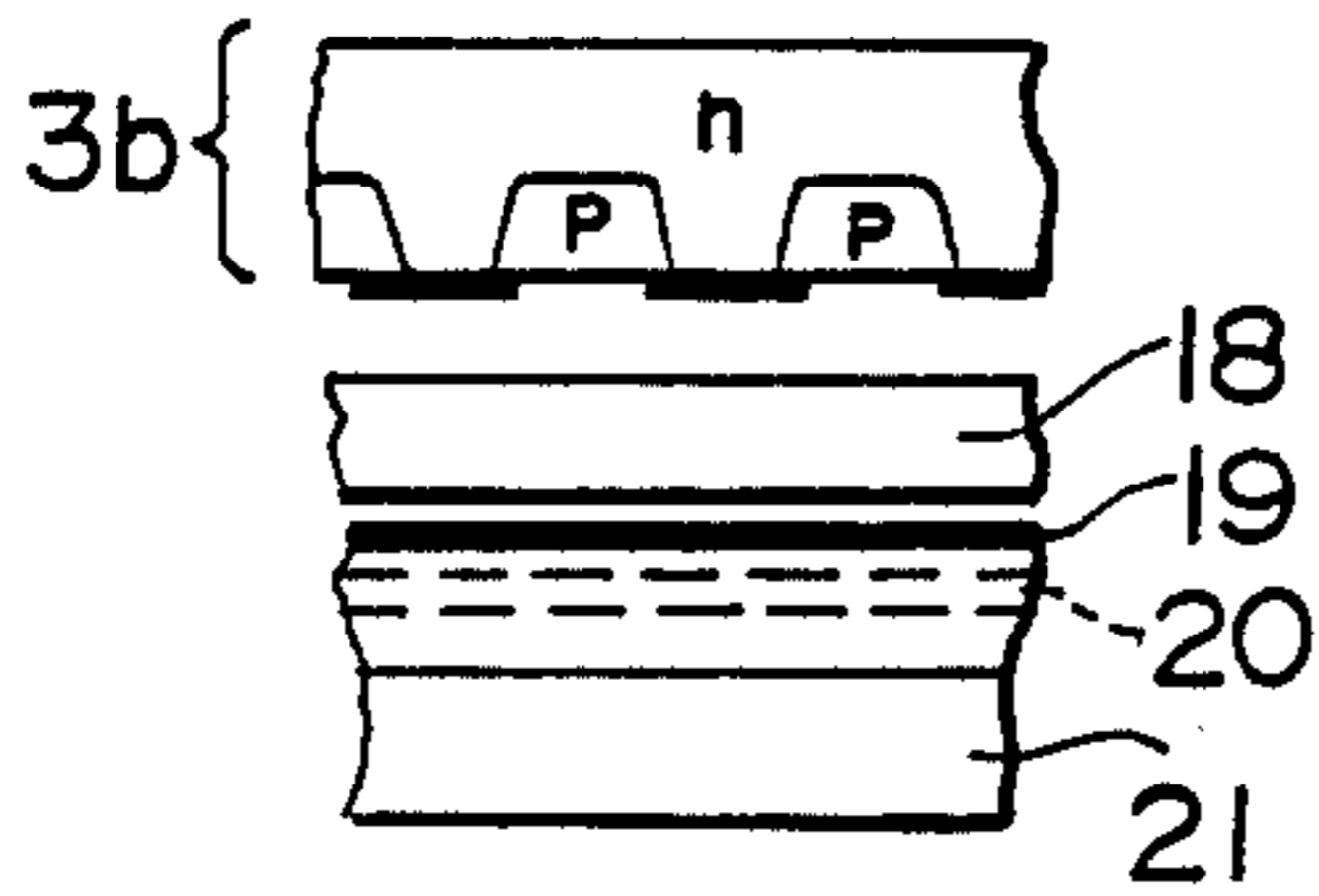


FIG. 8

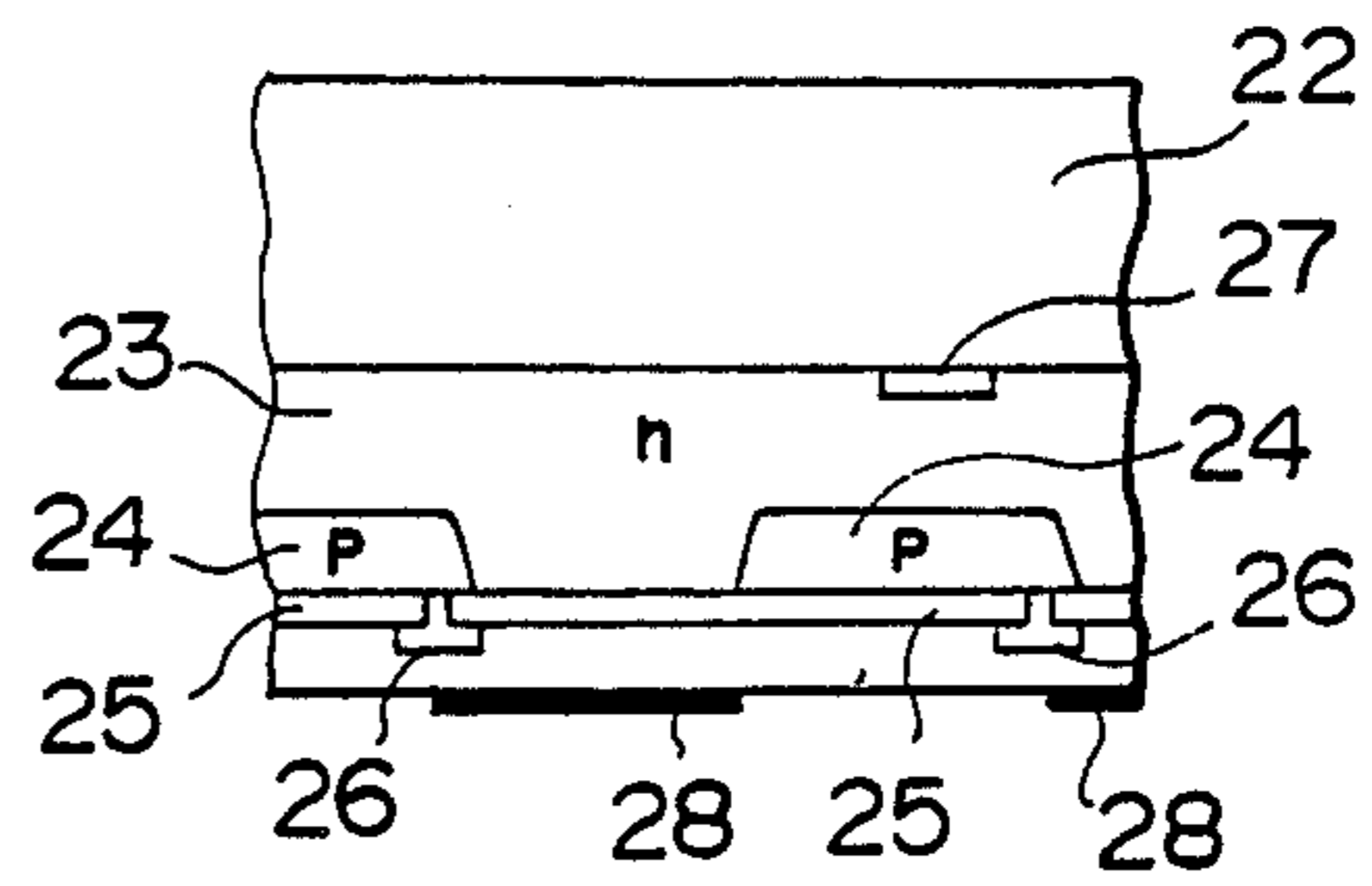
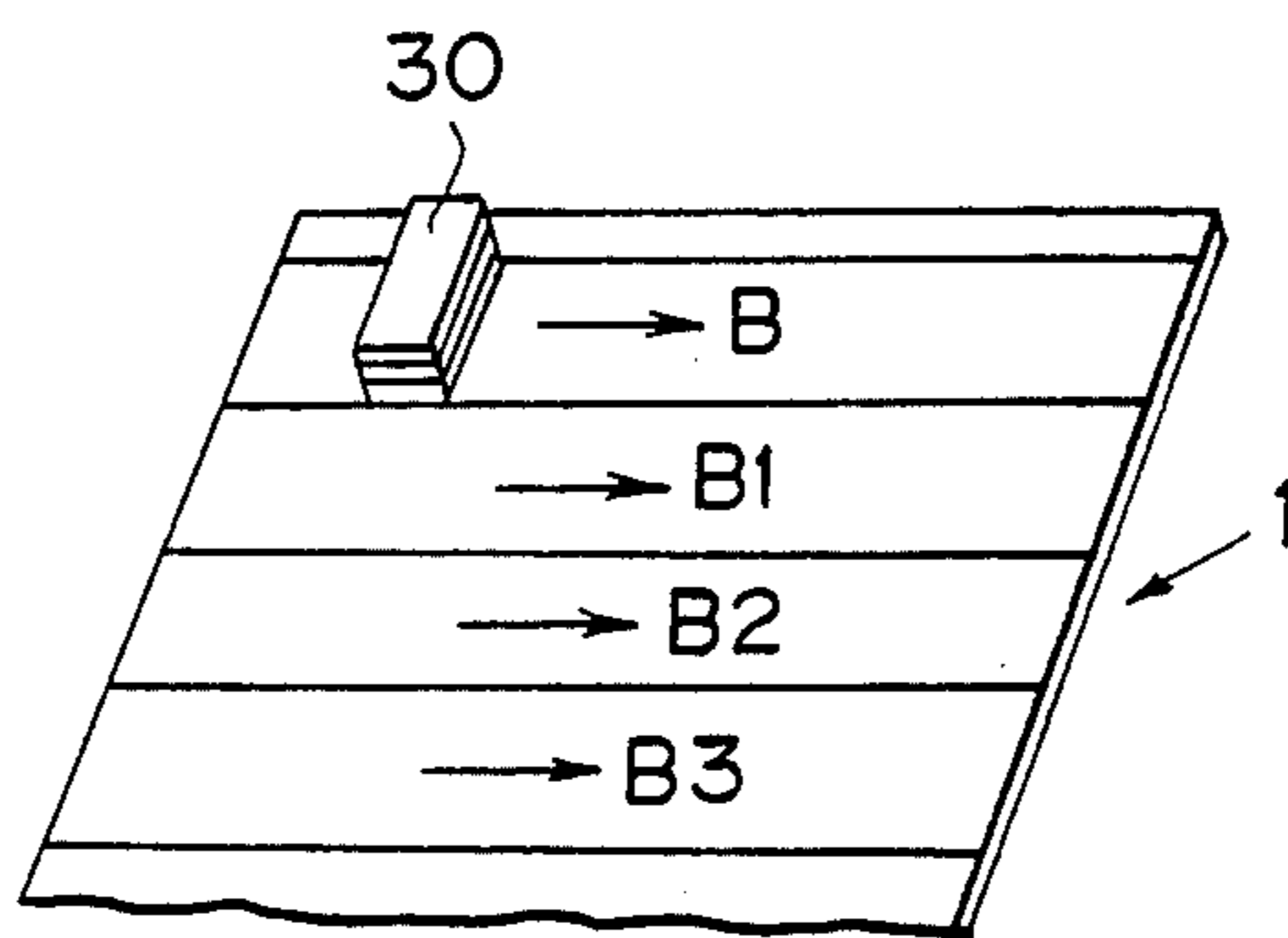


FIG. 9



RADIATION IMAGE READ-OUT APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a radiation image read-out apparatus for exposing a stimuable phosphor carrying a radiation image stored therein to stimulating rays which cause the stimuable phosphor to emit light in proportion to the radiation energy stored, and detecting and converting the emitted light into an electric image signal. This invention particularly relates to a radiation image read-out apparatus using a light source linearly emitting stimulating rays and a line sensor comprising many solid state photoelectric conversion devices as a photodetector for receiving the light emitted by the stimuable phosphor and converting it into an electric image signal.

2. Description of the Prior Art

A novel radiation image recording and reproducing system is disclosed, for example, in U.S. Pat. No. 3,859,527. The system comprises (i) exposing a stimuable phosphor sheet to a radiation passing through an object such as the human body to have a radiation image stored therein, (ii) scanning the stimuable phosphor sheet by stimulating rays which cause it to emit light in proportion to the radiation energy stored, (iii) detecting the emitted light and converting it into an electric image signal by use of a photodetector, and (iv) reproducing a visible image by use of the electric image signal.

In the aforesaid radiation image recording and reproducing system, during image read-out a semi-transparent mirror is positioned at an angle of 45° with respect to the stimuable phosphor sheet, and stimulating rays are made to pass through the semi-transparent mirror from the back thereof and to impinge upon the stimuable phosphor sheet. Light emitted by the stimuable phosphor sheet in proportion to the stored radiation energy when it is exposed to stimulating rays is laterally reflected by the semi-transparent mirror and is received by an image intensifier tube or a photomultiplier. Alternatively, stimulating rays are emitted from the rear surface of the stimuable phosphor sheet via an aperture, and light emitted by the front surface of the stimuable phosphor sheet is laterally reflected by a prism and received by an image intensifier tube. However, since the semi-transparent mirror or the prism is positioned far away from to the stimuable phosphor sheet, it is not always possible to efficiently guide the light emitted by the stimuable phosphor sheet, which is non-directional and weak.

On the other hand, Japanese Unexamined Patent Publication No. 58(1983)-121874 discloses an X-ray image converter comprising a light sensor utilizing a photoconductive semiconductor instead of a photomultiplier or an image intensifier tube, the light sensor being overlaid on the whole surface of the stimuable phosphor sheet. The light sensor comprises two transparent electrodes, which may be divided into parallel strip-like portions, and the photoconductive semiconductor is sandwiched therebetween. Image read-out is conducted by scanning the stimuable phosphor sheet by stimulating rays made to impinge upon the sheet from the outside via the light sensor. Or, an array of light emitting diodes exhibiting a spectrum of stimulating rays are positioned over the whole surface of the light sensor, and the light emitting diodes are sequentially turned on

to emit light for scanning the stimuable phosphor sheet. In the X-ray image converter, since the semiconductor layer is directly overlaid on the stimuable phosphor sheet, the possibility of a light receiving loss, i.e. of a loss of light emitted by the stimuable phosphor sheet in the space between the light receiving device and the stimuable phosphor sheet, is decreased. Therefore, it would be expected that the signal-to-noise ratio would increase.

However, actually, the aforesaid X-ray image converter has the drawbacks as described below.

(1) Since the light sensor is overlaid on the whole surface of the stimuable phosphor sheet, the photoconductive semiconductor is deteriorated when the stimuable phosphor sheet is subjected to noise erasing necessary for repeatedly using the stimuable phosphor sheet. (When the stimuable phosphor sheet is used repeatedly, radiation energy which remains on the stimuable phosphor sheet after the image read-out step and which constitutes noise in the next image recording and read-out is erased. Normally, noise erasing is conducted by exposing the stimuable phosphor sheet to a large amount of erasing light having a wavelength within the stimulating ray spectrum. Being exposed to the large amount of erasing light repeatedly, the semiconductor is deteriorated.) Also, since the weight and the volume of each stimuable phosphor sheet become large, the stimuable phosphor sheet becomes inconvenient for handling. Further, it is not always possible to actually overlay the light sensor on the whole surface of the stimuable phosphor sheet and to install the light emitting diode array over the whole surface thereof. Even when such a configuration can be realized, the cost of realizing the configuration is high.

(2) It is not always possible to obtain a photoconductive semiconductor exhibiting quick response characteristics. Therefore, it is not possible to increase the scanning speed of the stimulating rays (a light beam emitted by a stimulating ray source or light beams emitted by the light emitting diode array). Also, since the intensity of light emitted by a point light source such as the light emitting diode array is low, the exposure time at each portion of the stimuable phosphor sheet must be increased in order to cause it to emit light sufficiently. This also makes it impossible to increase the scanning speed.

(3) Even when the transparent electrodes are divided into parallel strip-like portions, the electrode area is still large. Therefore, a large dark current inevitably arises, and the capacitance is large. As a result, the signal-to-noise ratio cannot be improved so much.

SUMMARY OF THE INVENTION

The primary object of the present invention is to provide a radiation image read-out apparatus using solid state photoelectric conversion devices, which conducts image readout at a high speed and produces an electric image signal with a high signal-to-noise ratio.

Another object of the present invention is to provide a radiation image read-out apparatus which is easy to fabricate and handle and which can be made at a low cost.

The present invention provides a radiation image read-out apparatus comprising:

(i) a stimulating ray source for emitting stimulating rays linearly impinging upon a portion of a stimuable

phosphor sheet carrying a radiation image stored therein,

(ii) a line sensor comprising many solid state photoelectric conversion devices for receiving and photoelectrically converting light emitted by said stimuable phosphor sheet in proportion to the stored radiation energy when said stimuable phosphor sheet is exposed to the stimulating rays, said line sensor extending at least over the length of said portion of said stimuable phosphor sheet exposed linearly to the stimulating rays so as to stand face to face with said linearly exposed portion of said stimuable phosphor sheet,

(iii) a scanning drive means for moving said portion exposed linearly to stimulating rays and said line sensor with respect to said stimuable phosphor sheet along the surface of said stimuable phosphor sheet, and

(iv) a read-out means for sequentially reading out the outputs of said line sensor in accordance with the movement of said portion exposed linearly to stimulating rays and said line sensor with respect to said stimuable phosphor sheet.

In the radiation image read-out apparatus of the present invention, since no reflecting member such as a semi-transparent mirror or a prism need be used, it is possible to make the light receiving solid angle large. Therefore, it is possible to improve the signal-to-noise ratio. Also, since the solid state photoelectric conversion devices constituting the line sensor are divided in accordance with picture elements and have small areas, the dark current is small and the capacitance is small. Accordingly, it is possible to obtain a high signal-to-noise ratio.

Also, in the radiation image read-out apparatus of the present invention, since a plurality of picture elements are simultaneously exposed linearly to stimulating rays, it is possible to cause the stimuable phosphor sheet to emit light sufficiently even when a stimulating ray source emitting the stimulating rays of low intensity is used. Further, signals of picture elements are time-serially detected by use of an electric circuit, instead of scanning by a light spot. Therefore, it is possible to increase the read-out speed even when the read-out time per picture element is long.

Further, since the line sensor is separate from the stimuable phosphor sheet, the stimuable phosphor sheet is easy to handle, and noise erasing for repeatedly using the stimuable phosphor sheet can be conducted without deteriorating the photodetector. Also, since the sensor and the light source are markedly smaller than those in the apparatus of Japanese Unexamined Patent Publication No. 58(1983)-121874, the radiation image read-out apparatus of the present invention is easy to fabricate and can be made at a low cost.

In the radiation image read-out apparatus of the present invention, the stimuable phosphor sheet is linearly exposed to stimulating rays which are emitted by the stimulating ray source and which cause the stimuable phosphor sheet to emit light in proportion to the radiation energy stored. At the same time, the light emitted by the stimuable phosphor sheet is received by the line sensor. The line sensor comprises many solid state photoelectric conversion devices corresponding to respective picture elements and positioned at least over the length of the linearly exposed portion of the stimuable phosphor sheet. Upon receiving the light emitted by the stimuable phosphor sheet, the solid state photoelectric conversion devices convert the light into electric signals divided in accordance with the picture elements.

By reading out the electric signals by use of the read-out means, image information at the linearly exposed portion of the stimuable phosphor sheet is obtained. Thereafter, the portion exposed linearly to stimulating rays and the line sensor are moved relative to the stimuable phosphor sheet along the surface thereof, and the afore-said read-out step is repeated. In this manner, the whole radiation image stored in the stimuable phosphor sheet is read out.

In this specification, it should be noted that "moving a portion exposed linearly to stimulating rays and a line sensor with respect to a stimuable phosphor sheet" means movement of the portion exposed linearly to stimulating rays and the line sensor relative to the stimuable phosphor sheet and includes both the movement of the portion exposed linearly to stimulating rays and the line sensor with the sheet standing still and the movement of the sheet with the portion exposed linearly to stimulating rays and the line sensor standing still.

As the stimulating ray source for emitting stimulating rays linearly impinging upon a portion of a stimuable phosphor sheet, it is possible to use, for example, an array of light emitting diodes or semiconductor lasers positioned for simultaneously emitting light, or a non-directional light source comprising a fluorescent lamp, a xenon lamp, or the like and a slit or an aperture constituted by a row of small holes.

The line sensor is constituted by approximately linearly positioning the solid state photoelectric conversion devices such as photoconductive materials or photodiodes.

The line sensor should preferably have a length approximately equal to the length of the linearly exposed portion of the stimuable phosphor sheet, and is positioned in parallel with the linearly exposed portion of the sheet. The relationship $\lambda_1 > \lambda_2$ holds between the wavelength λ_1 of the stimulating rays and the wavelength λ_2 of the light emitted by the stimuable phosphor sheet. Therefore, depending on whether the band gaps of the solid state photoelectric conversion devices are larger or smaller than the energy of wavelength λ_1 , the place at which the stimulating ray source can be positioned changes, and the configurations which the solid state photoelectric conversion devices can assume change. Specifically, when the band gaps of the solid state photoelectric conversion devices are larger than the energy of λ_1 , the stimulating ray source may be positioned at the back of the line sensor and the stimulating rays may be made to impinge upon the stimuable phosphor sheet via the line sensor, or the stimulating ray source may be positioned on the back surface side of the stimuable phosphor sheet.

When the band gaps of the solid state photoelectric conversion devices are smaller than the energy of wavelength λ_1 , the stimulating ray source is positioned on the back surface side of the stimuable phosphor sheet, and the line sensor is positioned on the front surface side of the stimuable phosphor sheet. Further, a long wave cut filter for cutting the stimulating rays should preferably be positioned between the line sensor and the stimuable phosphor sheet.

When the length of the line sensor is equal to the width of the stimuable phosphor sheet, the line sensor and the portion exposed linearly to stimulating rays are moved in the length direction of the stimuable phosphor sheet. When the length of the line sensor is shorter than the width of the stimuable phosphor sheet, the line

sensor is positioned in the length direction of the stimu-
lable phosphor sheet. In this case, the line sensor is first
moved in the width direction of the stimu-
lable phosphor sheet to scan the sheet in the width direction
thereof. After scanning in the width direction is finished,
the stimu-
lable phosphor sheet is moved in the
length direction thereof by a distance equal to the
length of the linearly exposed portion thereof, and the
aforesaid scanning in the width direction is repeated. In
this manner, the whole surface of the stimu-
lable phosphor sheet is scanned.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B and 1C are a perspective view, a section-
al front view, and a sectional side view showing an
embodiment of the radiation image read-out apparatus
in accordance with the present invention, wherein a
linear stimulating ray source is positioned below a
stimu-
lable phosphor sheet and a line sensor is positioned
above the stimu-
lable phosphor sheet,

FIG. 2 is a perspective view showing another em-
bodiment of the radiation image read-out apparatus in
accordance with the present invention, wherein a line
sensor is positioned above a stimu-
lable phosphor sheet and a linear stimulating ray source is positioned at the
back of the line sensor,

FIG. 3A is a sectional front view showing the line
sensor and the linear stimulating ray source in the em-
bodiment of FIG. 2,

FIG. 3B is a sectional side view showing the line
sensor in the embodiment of FIG. 2,

FIG. 4 is an equivalent circuit diagram showing a line
sensor using photoconductors and a scanning circuit,

FIGS. 5A and 5B are a sectional front view and a
sectional side view showing a further embodiment of
the radiation image read-out apparatus in accordance
with the present invention, wherein a linear stimulating
ray source is positioned on the back surface side of a
stimu-
lable phosphor sheet,

FIGS. 6 and 7 are sectional views showing further
embodiments of the radiation image read-out apparatus
in accordance with the present invention, wherein pho-
todiodes are used as the solid state photoelectric con-
version devices,

FIG. 8 is an enlarged sectional view showing the line
sensor in FIGS. 6 and 7, and

FIG. 9 is a perspective view showing a modified form
of movement of the read-out system with respect to the
stimu-
lable phosphor sheet.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will hereinbelow be described
in further detail with reference to the accompanying
drawings.

FIG. 1A is a perspective view showing an embodi-
ment of the radiation image read-out apparatus in accor-
dance with the present invention, wherein a linear stimu-
lating ray source 2 is positioned below a stimu-
lable phosphor sheet 1 carrying a radiation image stored
therein and a line sensor 3 is positioned above the stimu-
lable phosphor sheet 1. FIG. 1B is a sectional front view
of FIG. 1, and FIG. 1C is a sectional side view of FIG.
1. As shown in detail in FIGS. 1B and 1C, the linear
stimulating ray source 2 extending in the width direc-
tion of the stimu-
lable phosphor sheet 1 is positioned
under the stimu-
lable phosphor sheet 1, and a slit mem-
ber 2A having an elongated slit extending in the width

direction of the stimu-
lable phosphor sheet 1 is posi-
tioned between the linear stimulating ray source 2 and
the stimu-
lable phosphor sheet 1. The line sensor 3 is
positioned above the stimu-
lable phosphor sheet 1 so as
to stand face to face with the slit in the slit member 2A.
The line sensor 3 comprises many solid state photoelec-
tric conversion devices 3A arrayed in the width direc-
tion of the stimu-
lable phosphor sheet 1, and a scanning
circuit 3B for transferring the charges accumulated in
the solid state photoelectric conversion devices 3A.

The linear stimulating ray source 2 linearly emits
stimulating rays onto the stimu-
lable phosphor sheet 1 via the slit member 2A. The portion of the stimu-
lable phosphor sheet 1 thus exposed linearly to stimulating
rays emits light in proportion to the radiation energy
stored therein. The light emitted by the linearly exposed
portion of the stimu-
lable phosphor sheet 1 is received
by the solid state photoelectric conversion devices of
the line sensor 3. Thus the devices 3A generate photo-
carriers and temporarily store signals obtained thereby.
The stored signals are sequentially read out by the scan-
ning circuit 3B, and read-out of one linear exposed
portion (corresponding to one scanning line) of the
stimu-
lable phosphor sheet 1 is finished.

Then, the stimu-
lable phosphor sheet 1 is moved with
respect to the linear stimulating ray source 2 and the
line sensor 3 by a distance equal to the spacing of one
scanning line in the direction as indicated by the arrow
A, and the aforesaid read-out step is repeated. The read-
out operation is repeated over the whole surface of the
stimu-
lable phosphor sheet 1, and the radiation image
stored in the whole surface of the sheet 1 is read out.

FIG. 2 is a perspective view showing another em-
bodiment of the radiation image read-out apparatus in
accordance with the present invention, wherein the
linear stimulating ray source 2 is positioned at the back
of the line sensor 3 on the same side of the stimu-
lable phosphor sheet 1. FIG. 3A is a partial sectional front
view showing the linear stimulating ray source 2 and
the line sensor 3 in the embodiment of FIG. 2, and FIG.
3B is a sectional side view showing the line sensor 3.
The line sensor 3 uses thin layer photoconductors and is
fabricated by stacking a light shielding layer 6 provided
with a slit or a series of small holes, a transparent elec-
trode layer 7, a photoconductor layer 8, and a transpar-
ent electrode layer 9 on a transparent substrate 5. By
dividing the transparent electrode layer 7 and/or the
transparent electrode layer 9 in accordance with picture
elements, many solid state photoelectric conversion
devices corresponding to the picture elements are
formed in the stack. In FIG. 3A, the transparent elec-
trode layer 9 is divided in accordance with the picture
elements.

The stimu-
lable phosphor sheet 1 carrying a radiation
image stored therein is linearly exposed to stimulating
rays emitted by the linear stimulating ray source 2 via
the line sensor 3, i.e. via the transparent substrate 5, the
slit or series of small holes in the light shielding layer 6,
the transparent electrode layer 7, the photoconductor
layer 8, and the transparent electrode layer 9. Light
emitted by the stimu-
lable phosphor sheet 1 in propor-
tion to the stored radiation energy when it is exposed to
stimulating rays is received by the photoconductor
layer 8 via the transparent electrode layer 9. The pho-
toconductor layer 8 is constituted by a photoconductor
exhibiting an energy gap E_g larger than the energy
 $hc/\lambda_1 (=h\nu_1)$ of the stimulating rays and smaller than
the energy $hc/\lambda_2 (=h\nu_2)$ of the light emitted by the

stimulable phosphor sheet 1. For example, it is possible to constitute the photoconductor layer 8 by using ZnS, ZnSe, CdS, TiO₂, ZnO, or the like when rare earth activated alkaline earth metal fluorohalide phosphor as disclosed in U.S. Pat. No. 4,239,968 is used as the stimu-

5 lable phosphor. When the stimulating rays contain a short wave component, a short wave cut filter 4 is inserted between the linear stimulating ray source 2 and the line sensor 3, thereby passing only a long wave component. The transparent electrode layer 9 (constituted, e.g. by ITO) is divided into very small units in the longitudinal direction of the line sensor 3. The potential difference arising between one divided unit of the transparent electrode layer 9 and the transparent electrode layer 7, i.e. the potential difference generated by accumulation of signals caused by photocarriers generated upon receiving of the light emitted by the stimulable phosphor sheet 1 within the photoconductor layer 8 between the transparent electrode layers 7 and 9, corresponds to an image signal of one pixel (picture element). The signals caused by photocarriers, which are obtained at the divided electrode units are time-serially read out by use of a shift register. In this manner, image signals of one scanning line are obtained. Then, the aforesaid operation is repeated each time the linear stimulating ray source 2 and the line sensor 3 are moved by a distance corresponding to the spacing of one scanning line in the direction as indicated by the arrow A. Thus the radiation image over the whole surface of the stimulable phosphor sheet 1 is read out as time-serial image signals.

A scanning circuit following the line sensor 3 will be described hereinbelow. FIG. 4 is an equivalent circuit diagram showing a line sensor and a scanning circuit. Signals caused by photocarriers generated when light ($h\nu$) emitted by a stimulable phosphor sheet impinges upon solid state photoelectric conversion devices 8a, 8b, and 8c using a photoconductor are accumulated at capacitors C1, C1, C1 of the solid state photoelectric conversion devices 8a, 8b, and 8c. The accumulated signals of the photocarriers are sequentially read out by switching of a switch section 10 carried out by a shift register 11, and time-serial image signals are obtained thereby. The image signals are then amplified by an amplifier 12 and are sent out from an output terminal 13 of the amplifier 12.

The MOS section comprising the switch section 10 and the shift register 11 may be replaced by a charge coupled device (CCD).

FIGS. 5A and 5B are partial sectional front view and a sectional side view showing configurations of a linear stimulating ray source and a line sensor in a further embodiment of the radiation image read-out apparatus in accordance with the present invention, which provides approximately the same effects as those in the aforesaid embodiments. Stimulating rays emitted by a linear stimulating ray source 21 are made to impinge upon the back surface of a stimulable phosphor sheet 18 via a slit or small holes of a light shielding layer 19. Light emitted by the stimulable phosphor sheet 18 when it is exposed to the stimulating rays is received by a line sensor 3a positioned on the front surface side of the sheet 18 so as to stand face to face with the linear stimulating ray source 21. The line sensor 3a is fabricated by stacking an electrode layer 15, a photoconductor layer 16, and a divided transparent electrode layer 17 on a light shielding substrate 14. When the stimulating rays contain a short wave component, a short wave cut filter

20 is inserted between the linear stimulating ray source 21 and the stimulable phosphor sheet 18, thereby passing only a long wave component. In this embodiment, since the stimulating rays do not pass through the photoconductor layer 16, it is possible to use a photoconductor fabricated of, for example, amorphous SiH, CdS(Cu), ZnS(Al), CdSe, or PbO, which exhibits an energy gap E_g smaller than the energy hc/λ_1 of the stimulating rays. However, in this case, it is necessary to position a long wave cut filter between the line sensor 3a and the stimulable phosphor sheet 18 so that stimulating rays leaking from the surface of the sheet 18 do not impinge upon the line sensor 3a.

In the aforesaid embodiment, photoconductors are used as the solid state photoelectric conversion devices. However, it is also possible to use photodiodes instead of the photoconductors.

FIG. 6 is a sectional view showing a still further embodiment of the radiation image read-out apparatus in accordance with the present invention, wherein the linear stimulating ray source 2 is positioned at the back of a line sensor 3b comprising photodiodes and stimulating rays are made to impinge upon the stimulable phosphor sheet 1 via the line sensor 3b. FIG. 7 is a sectional view showing another embodiment of the radiation image read-out apparatus in accordance with the present invention, wherein the linear stimulating ray source 21 is positioned on the back surface side of the stimulable phosphor sheet 18 and the line sensor 3b comprising photodiodes is positioned on the front surface side of the stimulable phosphor sheet 18. The embodiment of FIG. 6 corresponds to the embodiment of FIG. 3A, and the embodiment of FIG. 7 corresponds to the embodiment of FIG. 5A. Therefore, in FIGS. 6 and 7, similar elements are numbered with the same reference numerals with respect to FIGS. 3A and 5A.

FIG. 8 is an enlarged sectional view showing the configuration of the line sensor 3b in the embodiment of FIGS. 6 and 7. The line sensor 3b is fabricated by stacking an n-layer 23 and a divided p-layer 24 on a crystal substrate 22, thereby forming a photodiode array. A transparent insulation layer 25 made of phosphors silicate glass, or the like, and a light shielding layer 28 provided with a slit or small holes are overlaid on the diode layers 23 and 24. An electrode 27 is positioned adjacent the n-layer 23, and the other electrode 26 is positioned adjacent the p-layer 24. The electrode 26 is fabricated of aluminium or the like.

When photodiodes fabricated of ZnS, ZnSe, or the like, which exhibit an energy gap E_g larger than the energy hc/λ_1 of the stimulating rays are used as the solid state photoelectric conversion devices, both embodiments of FIGS. 6 and 7 are applicable. When photodiodes fabricated of Si, GaP, amorphous silicon, or the like, which exhibit an energy gap E_g smaller than the energy hc/λ_1 of the stimulating rays are used as the solid state photoelectric conversion devices, only the embodiment of FIG. 7 is applicable.

As the method of guiding the light emitted by the stimulable phosphor sheet to the solid state photoelectric conversion devices, the line sensor should most preferably be closely contacted with the stimulable phosphor sheet. However, it is also possible to position a micro-lens array or optical fibers in the form of a flat cable between the line sensor and the stimulable phosphor sheet, thereby guiding the light emitted at each pixel to each solid state photoelectric conversion device of the line sensor in one-to-one relation.

In the aforesaid embodiments, the read-out system comprising the linear stimulating ray source and the line sensor is extended in the width direction of the stimu-
 5 lable phosphor sheet, and is moved with respect to the stimu-
 lable phosphor sheet in the length direction of the sheet, as shown in FIGS. 1A and 2. However, as shown in FIG. 9, it is also possible to use a read-out system 30
 10 comprising a relatively short line sensor and a relatively short linear stimulating ray source so that the read-out system 30 extends in the length direction of the stimu-
 lable phosphor sheet 1. In this case, the read-out system 30 is moved in the width direction of the sheet 1 as indicated by the arrow B and is then shifted in the
 15 length direction of the sheet 1, thereby scanning in the directions of B1, B2, . . .

We claim:

1. A radiation image read-out apparatus comprising:
 - (i) a stimulating ray source for emitting stimulating rays linearly impinging upon a portion of a stimu-
 20 lable phosphor sheet carrying a radiation image stored therein by stored radiation energy, said stimu-
 lating ray source being positioned on a first side of said stimu-
 lable phosphor sheet,
 - (ii) a line sensor comprising many solid state photoe-
 25 lectric conversion devices for receiving and photo-
 electrically converting light emitted by said radia-
 tion image stored in said stimu-
 lable phosphor sheet in proportion to said stored radiation energy when
 said stimu-
 lable phosphor sheet is exposed to the
 stimulating rays, said line sensor being positioned 30
 on a second side of said stimu-
 lable phosphor sheet
 opposite said stimulating ray source such that said
 stimu-
 lable phosphor sheet is positioned between
 said stimulating ray source and said line sensor, said
 line sensor extending at least over the length of said 35
 portion of said stimu-
 lable phosphor sheet exposed
 linearly to the stimulating rays so as to stand face to
 face with said linearly exposed portion of said
 stimu-
 lable phosphor sheet,
 - (iii) scanning drive means for moving said portion 40
 exposed linearly to stimulating rays and said line
 sensor with respect to said stimu-
 lable phosphor
 sheet along the surface of said stimu-
 lable phosphor
 sheet, and
 - (iv) read-out means for sequentially reading out the 45
 outputs of said line sensor in accordance with the
 movement of said portion exposed linearly to stimu-
 lating rays and said line sensor with respect to said
 stimu-
 lable phosphor sheet.
2. An apparatus as defined in claim 1 wherein signals 50
 caused by photocarriers generated on the basis of the
 light, which is emitted by said stimu-
 lable phosphor
 sheet and received by said solid state photoelectric
 conversion devices, are temporarily accumulated and
 then read out by use of said solid state photoelectric 55
 conversion devices and said read-out means.
3. An apparatus as defined in claim 2 wherein said line
 sensor has a length approximately equal to the width of
 said stimu-
 lable phosphor sheet and is positioned in the
 width direction of said stimu-
 lable phosphor sheet, and 60
 said scanning drive means moves said line sensor in the
 length direction of said stimu-
 lable phosphor sheet.
4. An apparatus as defined in claim 1 wherein said line
 sensor has a length approximately equal to the width of
 said stimu-
 lable phosphor sheet and is positioned in the 65
 width direction of said stimu-
 lable phosphor sheet, and
 said scanning drive means moves said line sensor in the
 length direction of said stimu-
 lable phosphor sheet.

5. An apparatus as defined in claim 4 wherein said line
 sensor is comprised of a light shielding layer provided
 with a slit or small holes, a first transparent electrode
 layer, a photoconductor layer, and a second transparent
 electrode layer disposed on a transparent substrate in
 this order, and at least one of said first transparent elec-
 10 trode layer and said second transparent electrode layer
 is divided into sections each corresponding to one pic-
 ture element.

6. An apparatus as defined in any of claims 1 to 4
 wherein said line sensor is comprised of a first transpar-
 ent electrode layer, a photoconductor layer, and a sec-
 ond transparent electrode layer disposed on a light
 shielding substrate in this order, and at least one of said
 15 first transparent electrode layer and said second trans-
 parent electrode layer is divided into sections each cor-
 responding to one picture element.

7. An apparatus as defined in any of claims 1 to 4
 wherein said line sensor is comprised of an n-layer, a
 divided p-layer, a transparent insulation layer, and a
 light shielding layer provided with a slit or small holes
 disposed on a crystal substrate to form a photodiode
 array in this order, a first electrode is positioned adja-
 cent said n-layer, and a second electrode is positioned
 25 adjacent said p-layer.

8. A radiation image read-out apparatus comprising:

- (i) a stimulating ray source for emitting stimulating
 rays linearly impinging upon a portion of a stimu-
 lable phosphor sheet carrying a radiation image
 stored therein by stored radiation energy, said stimu-
 lating ray source being positioned on a first side of
 said stimu-
 lable phosphor sheet,
- (ii) a substantially transparent line sensor comprising
 many solid state photoelectric conversion devices
 for receiving and photoelectrically converting
 light emitted by said radiation image stored in said
 stimu-
 lable phosphor sheet in proportion to said
 stored radiation energy when said stimu-
 lable phos-
 phor sheet is exposed to the stimulating rays, said
 line sensor being positioned on said first side of said
 stimu-
 lable phosphor sheet such that said line sensor
 is positioned between said stimu-
 lable phosphor
 sheet and said stimulating ray source, said line
 sensor extending at least over the length of said
 portion of said stimu-
 lable phosphor sheet exposed
 linearly to the stimulating rays by said stimulating
 ray source through said line sensor so that said line
 sensor stands face to face with said linearly exposed
 portion of said stimu-
 lable phosphor sheet,
- (iii) scanning drive means for moving said portion
 exposed linearly to stimulating rays and said line
 sensor with respect to said stimu-
 lable phosphor
 sheet along the surface of said stimu-
 lable phosphor
 sheet, and
- (iv) read-out means for sequentially reading out the
 outputs of said line sensor in accordance with the
 movement of said portion exposed linearly to stimu-
 lating rays and said line sensor with respect to said
 stimu-
 lable phosphor sheet, wherein
- (v) the photoelectric conversion devices comprise a
 photoconductor exhibiting an energy gap larger
 than the energy of the stimulating rays and smaller
 than the energy of the light emitted by the radiation
 image stored in the stimu-
 lable phosphor sheet, and
 wherein the stimulating rays have a wavelength
 different from that of the light emitted by the radia-
 tion image stored in the stimu-
 lable phosphor sheet,
 said energy gap being in a range from 2.0 to 2.7 ev.

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9. An apparatus as defined in claim 8 wherein signals caused by photocarriers generated on the basis of the light, which is emitted by said stimuable phosphor sheet and received by said solid state photoelectric conversion devices, are temporarily accumulated and then read out by use of said solid state photoelectric conversion devices and said read-out means.

10. An apparatus as defined in claim 9 wherein said line sensor has a length approximately equal to the width of said stimuable phosphor sheet and is positioned in the width direction of said stimuable phos-

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phor sheet, and said scanning drive means moves said line sensor in the length direction of said stimuable phosphor sheet.

11. An apparatus as defined in claim 8 wherein said line sensor has a length approximately equal to the width of said stimuable phosphor sheet and is positioned in the width direction of said stimuable phosphor sheet, and said scanning drive means moves said line sensor in the length direction of said stimuable phosphor sheet.

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